and can be affected by a reduction in the per-minute access rate or the choice to recover the PSL revenue requirement on a per-minute rather than a per-line basis.

We begin with 1996 toll minutes and calculate the percent change in toll demand after access reform reduces the per-minute access cost levied on IXCs. We use a constant elasticity of demand curve to obtain a ratio of pre and post exchange access reform toll prices. Our estimate of post reform toll prices depend on (i) fixed parameters regarding the FCC's access reform plan and (ii) two assumptions—whose values range from 0 to 1—which represent the degree to which IXCs pass per-minute exchange access charge reductions through to end users in the form of lower prices and the degree to which IXCs recover their PSL costs through higher toll prices. We then calculate the change in toll demand and ultimately exchange access demand. Finally, we calculate total revenue and total cost using pre and post exchange access reform prices, incremental costs and quantities to estimate changes in IXC and LEC contribution resulting from exchange access reform.

IV. Study Results

Our understanding of the parameters the FCC is considering regarding how NTS costs will be recovered beginning in 1998 (i.e., new PSL charges) and the assumptions we made (e.g., regarding demand elasticity) are fully described in the attached Technical Appendix. Based on these assumptions we have estimated that LECs will be required to reduce per-minute access rates by $3.340 billion and IXCs will be required to pay PSL charges of $3.340 billion. Using these parameters, and focusing on only the question of whether IXCs will pass through the access cost reduction, we make the following observations.

The Local Exchange Company (LEC) per-minute margin (price less cost) will be reduced and the per-minute margin of IXCs will increase or remain the same depending upon how much of the access rate reduction they flow through to their toll customers. If IXCs choose not to pass through all the access reduction to toll, the IXC's margin is increased. If all cost reduction is passed through, the IXC's margin will remain the same. We expect that IXC's will make a profit maximizing decision about how much of the access cost reduction to pass through in their toll prices.

Our analysis also indicates that the access service demand change (stimulation) would range from 0 to 7.1 percent depending upon the amount of access cost reduction passed through in IXC toll prices. The associated contribution changes for the IXC industry range from $1.616 to $3.340 billion and from $0.000 to $0.455 billion for the LEC industry. Tables 1 and 2 show additional information about the price, revenue and cost changes for these scenarios.[4]

In Table 1, we show the result that assumes the IXC toll market is perfectly competitive. Under such a condition, the market would force all IXCs to fully pass through their access service input cost reduction. The resultant toll price decrease would stimulate demand (7.1 percent) and result in contribution increases of $1.616 billion for the IXCs and $0.455 billion for the LECs.

Table 1
The Perfectly Competitive Solution

Full access reduction pass through; PSL recovered via a flat end user charge

	IXC Industry	LEC Industry
Demand Stimulation	7.05%	7.05%
Price Change	(1.62¢)	(1.62¢)
Change in Total Revenue (billions)	$2.373	$0.611
Change in Total Cost (billions)	$0.757	$0.156
Change in Contribution (billions)	$1.616	$0.455

Table 2 shows these results if perfect competition does not prevail—if the IXC industry can somehow retain all or a portion of the cost savings from reduced access rates—they would enjoy an even greater increase in contribution at the expense of the LEC industry which would, in the limit, experience no increase in contribution. Under these circumstances, the IXCs would enjoy a $3.340 billion increase in contribution and the LEC's contribution would remain unchanged.

Table 2
The Monopoly Solution

[4] In addition, the initial period values of other variables are as follows: toll price = 17.9¢ per minute; exchange access price = 5.81¢ per minute; quantity = 206.823 billion minutes; IXC incremental cost = 1.00¢ per minute; and LEC incremental cost =1.07¢ per minute.

No access reduction pass through; PSL recovered via a flat end user charge		
	IXC Industry	LEC Industry
Demand Stimulation	0.0%	0.0%
Price Change	0.00¢	1.62¢
Change in Total Revenue (billions)	$3.340	$0.000
Change in Total Cost (billions)	($0.00)	$0.000
Change in Contribution (billions)	$3.340	$0.000

AN ANALYSIS OF THE EFFECTS OF EXCHANGE ACCESS REFORM ON DEMAND STIMULATION

TECHNICAL APPENDIX

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Consulting Economists

TECHNICAL APPENDIX

I. INTRODUCTION

In this appendix we discuss the economics of switched exchange access and describe our calculation of the change in the quantity of switched access minutes demanded as a result of exchange access reform. Recognizing the derived demand nature of exchange access we conclude that under access reform the level of quantity demanded, all else equal, is affected by (i) the degree to which IXCs pass per-minute switched access price reductions through to reduce per-minute toll prices and (ii) the means employed by IXCs to recover the newly imposed Presubscribed Line (PSL) charge.

II. THEORY

Unlike a final product—one not used in the production of another product—exchange access is used in the production of a final product, toll calls, and is thus considered a factor of production. The demand for any factor is a function of (i) the factor price, (ii) demand in the product market where the factor is employed, and (iii) the prices of other factors. Changes in the quantity of exchange access demanded thus arise from both changes in the price of access and changes in toll market equilibrium.

A. Derived-Demand Functions

Since demand for any factor of production (in this case switched access used in the production of toll) depends on equilibrium conditions in the product market, economists use the term derived demand to describe its demand. Derived demand for any factor can be written as:

(1) $$x_i = f\left(w_i, w_j, y\right)$$

where: x_i is the derived demand, w_i is price of the i^{th} factor, w_j is price of the j^{th} factor and y is the product market equilibrium output.

A change in the price of a factor will induce two effects (i) a substitution effect which causes any given product output level to be produced using more or less of the factor and (ii) an output effect which indicates that a change in the price of a factor induces a change in product market equilibrium. These effects can be written as:

(2) $$\frac{\partial x_i}{\partial w_i} = \frac{\partial x_i}{\partial w_i}\left(y_{constant}\right) + \frac{\partial x_i}{\partial w_i}\left(y_{changes}\right).$$

The first term on the right hand side of equation (2) is the substitution effect while the second term is the output effect. Using Shepard's lemma which uses the Envelope theorem to show that the constant output demand function for x_i can be found by partially differentiating total costs with respect to w_i, it can be shown that

$$\frac{\partial x_i}{\partial w_i} = \frac{\partial^2 TC}{\partial w_i^2}$$

which must be negative if costs are truly minimized. The second term can be analyzed by using a "chain rule" type argument to examine the causal links that determine how changes in w_i affect the demand for x_i. We can write the second term as:

(3) $$\frac{\partial x_i}{\partial w_i}\left(y_{changes}\right) = \left(\frac{\partial x_i}{\partial y}\right)\left(\frac{\partial y}{\partial P}\right)\left(\frac{\partial P}{\partial MC}\right)\left(\frac{\partial MC}{\partial w_i}\right)$$

where P, MC and y are the price, marginal cost and output of the final product, respectively. For the output effect, changes in w_i affect x_i indirectly through changes in marginal costs, prices and outputs. The first and last term are equal in sign and therefore their product is positive.[1] The second term shows how market demand responds to price changes and, in the usual case,

$$\frac{\partial y}{\partial P} < 0.$$

Since price equals marginal costs for profit maximization under perfect competition,

$$\frac{\partial P}{\partial MC} = 1.$$

Therefore, the second term on the right hand side of equation (2) is negative as well.

The magnitude of the quantity change of a factor depends on the size of the substitution and output effects. The size of the substitution effect depends on (i) the elasticity of factor substitution[2] (ii) the length of time allowed for adjustment, and (iii) how important the factor is in total production costs. The size of the output effect depends on the size of the cost change brought about by a change in factor prices and the final product's own price elasticity of demand.

1. Substitution Effect

An IXC's production function for the provision of toll can be described as follows:

(4) $$Q_{toll} = f(x_a, \mathbf{x})$$

[1] See C. F. Ferguson, *The NeoClassical Theory of Production and Distribution*, Cambridge University Press (1969).

[2] Some firms may find it easy to substitute inputs to produce the same output level after the change in factor price, while other firms may produce with a fixed-proportions technology, and for them substitution is impossible.

where Q_{toll} represents toll output per minute, x_a is the quantity of per-minute exchange access (both originating and terminating) and $\mathbf{x}$ is a vector representing other factors used to produce toll. The substitution effect is the proposition that if the price of exchange access is altered other inputs ($\mathbf{x}$) could be substituted for exchange access holding output constant. It is likely that the elasticity of substitution of x_a for $\mathbf{x}$ is extremely low because an IXC cannot easily substitute x_a for other inputs contained in $\mathbf{x}$. In fact, Q_{toll} is likely to exhibit characteristics similar to a fixed proportions technology, thus making substitution of $\mathbf{x}$ for x_a or x_a for $\mathbf{x}$ extremely difficult.

In a more general statement of Q_{toll}, x_a can be expanded to (i) switched access, (x_{swa}) (ii) special access, (x_{spa}) (iii) facilities bypass through CAPs, (x_{cap}) and (iv) use of unbundled network elements (x_e).[3] An IXC's production function can then be written as:

(5) $$Q_{toll} = f\left(x_{swa}, x_{spa}, x_{cap}, x_e, \mathbf{x}\right),$$

where since these factors are substitutes, the firm—except for technology constraints—will choose one to minimize total costs. A change in the price of switched access could, therefore, cause a change in the demand for other access arrangements. Since the FCC is likely to reduce per-minute switched exchange access rates, we would expect to observe, holding other factors constant, some migration from the other exchange access arrangements, namely x_{spa}, x_{cap}, and x_e to switched exchange access, x_{swa}. The magnitude of the substitution effect depends primarily on price difference between switched access and the other access arrangements.

We assume this rate restructure for switched access will not significantly affect the substitution of switched access for special or CAP access. Special and CAP access services offer end users greater service choices such as wideband data, video and program audio services at rates that are substantially below current and probable future switched access rates under access reform. Special and CAP rates bypass the NTS costs assigned to the interstate jurisdiction.[4] They also provide different value to consumers than switched access through, for example, alternative routing thus providing greater reliability. In addition, special and CAP access customers are primarily inframarginal customers. Theory suggests that changes in switched access prices induce marginal, not inframarginal, users to substitute. Many special and CAP access customers—especially those who account for a large percent of minutes and revenues—have a low switched access price point.[5] In our model the exchange access rate is reduced from 5.81¢ to 4.19¢ per-minute. The likely effect of this reduction—when compared to estimates of special access prices—is to reduce the degree of substitution of special access for switched access, not to attract special access customers back to switched access.

[3] One can also include customer construction of own facilities to bypass LEC as well as end to end bypass.

[4] FCC, Fiber Deployment Update End of Year 1995, Jonathan M. Kraushaar, Industry Analysis Division (July 1996), notes that "CAPs appear to have motivated local exchange carriers to price special access closer to cost..." at 34.

[5] Assume that a T-1 line is already in place and costs the end user $300 per month. If it is used 50 percent of the time during the normal business day, the price per minute is 0.24 cents [$300/(24 voice circuits x 4 hours x 60 minutes x 4.285 weeks per month x 5 days per week)].

We make the simplifying assumption that substitution arising from unbundled network elements is likely to be limited initially since these are relatively new factors that can be used in the provision of toll.[6] Therefore, we assume the substitution effect from special and CAP access is zero and we ignore the possible effects arising from the existence of unbundled network elements.

2. Output Effect

The magnitude of the output effect depends on the interaction of the terms contained in equation (3) above and rewritten below for convenience.

$$(3) \qquad \frac{\partial x_i}{\partial w_i}(y_{changes}) = \left(\frac{\partial x_i}{\partial y}\right)\left(\frac{\partial y}{\partial P}\right)\left(\frac{\partial P}{\partial MC}\right)\left(\frac{\partial MC}{\partial w_i}\right)$$

Changes in w_i affect x_i indirectly through changes in marginal costs, prices and outputs. A change in the price of exchange access w_i (assuming it is a variable cost) will shift the marginal cost curve of the firm which affects the long-run equilibrium final toll product price and quantity and, in turn, determines the demand for x_i.

a. Exchange Access and Long Distance Rates

Under perfect competition, the term $\frac{\partial P}{\partial MC}$ in equation (3) is equal to 1 because cost changes are fully passed through to consumers. In analyzing exchange access and toll, the price of exchange access is properly viewed as a component of the marginal cost of toll. In a competitive market under general circumstances, we would expect industry-wide reductions in marginal costs (stemming from input price reductions or other cost changes that affect all firms) to be fully reflected in output prices. Therefore, if the assumption that the long distance product market is competitive is valid, we would expect, all else constant, a change in per-minute access prices to be fully reflected in output prices, ($\frac{\partial P_{toll}}{\partial P_a} = 1$).

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[6] The Stimulation analysis which follows is based on the assumption that all else is equal. The existence of unbundled network elements weakens this assumption and affects the *ex-ante* (before access reform) total amount of switched access that is used to calculate demand stimulation. To the extent that equilibrium switched access rates after exchange access reform differ from network element rates, the amount of switched access minutes will be lower. For an economic analysis on the interaction between the Part 69 exchange access regime and unbundled network elements, see Agustin J. Ros and Susan McMaster, "Exchange Access, Interconnection and Unbundled Network Elements: Where Will it Lead?," Working Paper presented at the Advanced Workshop in Regulation and Competition: Network Industries in Transition, May 21-23, 1997.